3.3.4 Even-Interval Streamflow and Water Quality Monitoring

Regular interval flow sampling was conducted on a biweekly basis during the summer and on a weekly basis in the winter to coincide with water quality sampling. Measurements were difficult to obtain due to low base flow conditions during summer months at both Chumash and Walters Creeks. Unfortunately, insufficient paired flow data is available to perform statistical analysis of flow, along with water quality data, or to evaluate percent reductions in pollutant loadings. Nonetheless, stream flow from Chumash and Walters Creeks is highly correlated (R^2=78.7 %, p=0.000), and significant water quality results were found without the aid of flow data. These are discussed in the following sections. Flow data is shown in Figure 3.18.

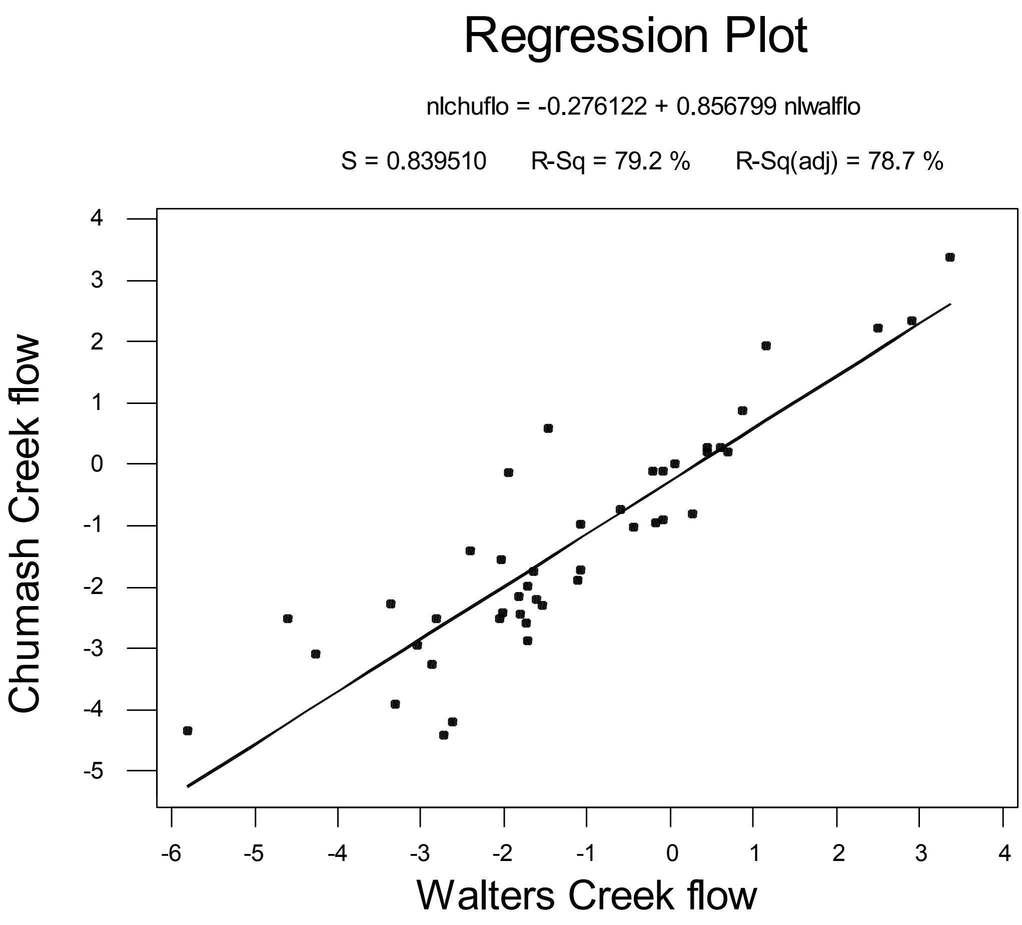

Figure 3.18. Regression between log Chumash and Walters Creek flow from 1993 to 1999.

3.3.5 Statistical Analyses of Even-Interval Water Quality Data

Water Temperature

NMP Project staff found statistically significant decreases in water temperature as a result of BMP implementation (Table 3.9) at Chumash Creek. Figure 3.13 and 3.14 display weekly water temperature for pre-BMP implementation and post-BMP implementation. One year of paired data is shown to illustrate changes. Because Walters Creek becomes dry early in the summer, the paired data shown extends from December until June. In 1995, during the pre-BMP period (Figure 3.19), the water temperature between creeks is similar. In 2001, during post-BMPs (Figure 3.20), an increase in water temperature is apparent at Walters Creek .

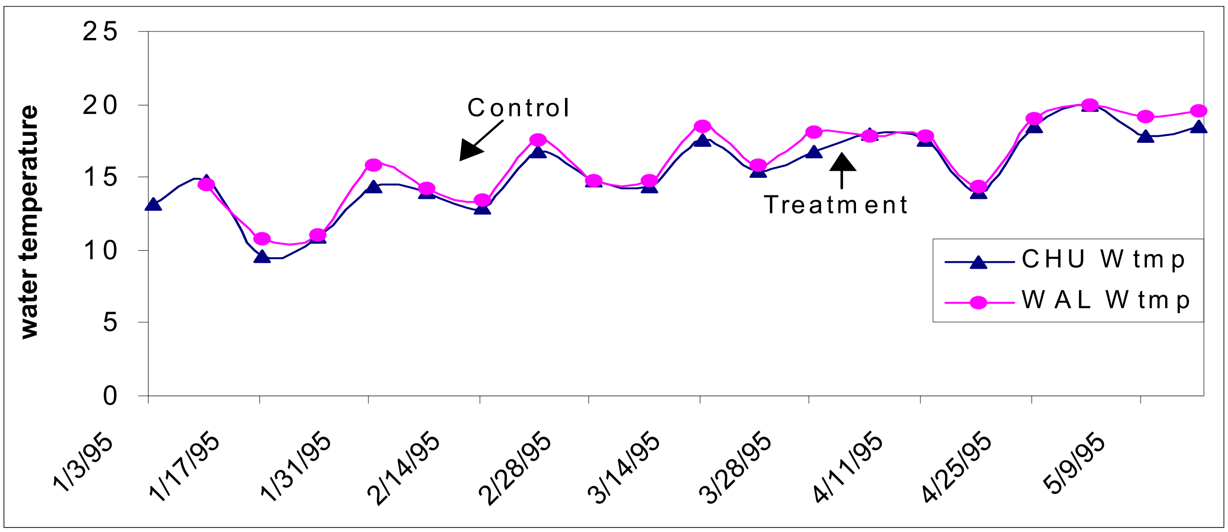

Figure 3.19. 1995 even-interval water temperature for Chumash and Walters Creek representing pre-BMP implementation in the Chumash Creek watershed.
Water temperature is in º Celsius.

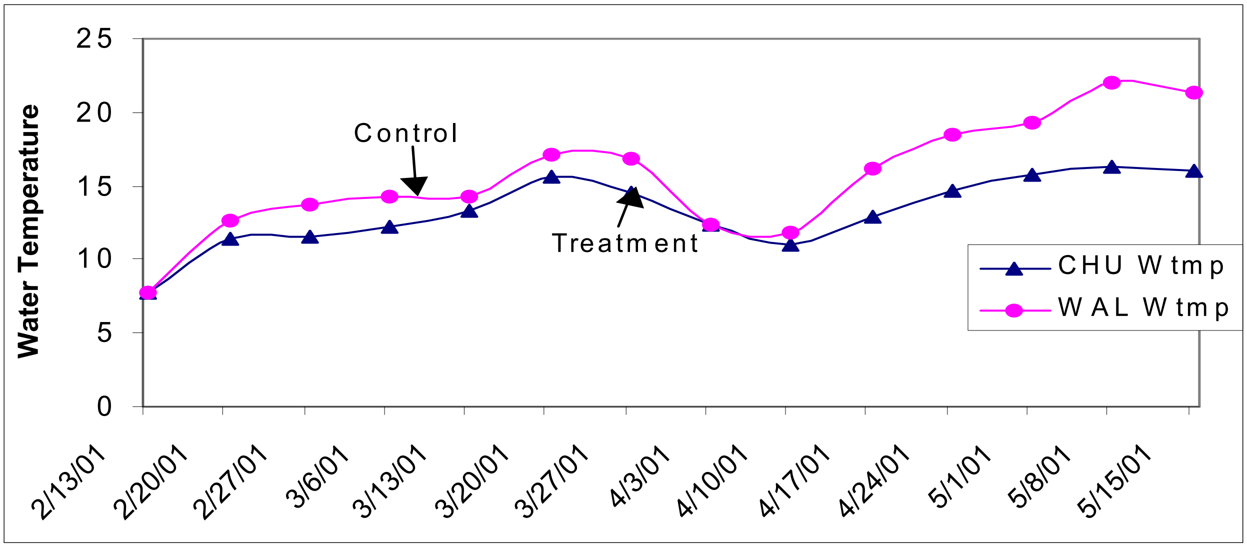

Figure 3.20. 2001 even-interval water temperature for Chumash and Walters Creek representing post-BMP implementation in the Chumash Creek watershed.
Water temperature is in º Celsius.

Repeated measures linear regression tests for significant differences were applied between the pre-BMP period and the post-BMP period. Walters Creek, the control creek, has a mean of 18.02°C. During pre-BMP implementation, a difference of 0.87 °C between mean Chumash Creek and mean Walters Creek water temperature was found to be significantly different (Table 3.13.) Following BMP implementation, Chumash Creek water temperature dropped on average an additional 1.42°C and again water temperature differences between Chumash and Walters Creeks was statistically significant (p=0.0029). The former describes a natural difference found between the creeks during the 'calibration' or pre-BMP period, the latter confirms the positive effect of the installed BMPs in the Chumash watershed.

Table 3.13. Statistical results for water temperature °C

Time Period	**Walters Creek**	**Chumash Creek**	**p value**
Pre-BMP mean	18.02*[1]	17.15	0.0175*
Post-BMPs mean		15.73	0.0029**

*α=0.05 **α=0.01, *[1]The mean of Walters Creek water temperature for the study. It is used as the intercept for the regression model (see page 7 for further explanation).

The difference found in the statistical test is apparent in Figure 3.21, where the gap between Chumash and Walters Creek yearly mean water temperature widens during the post-BMP period.

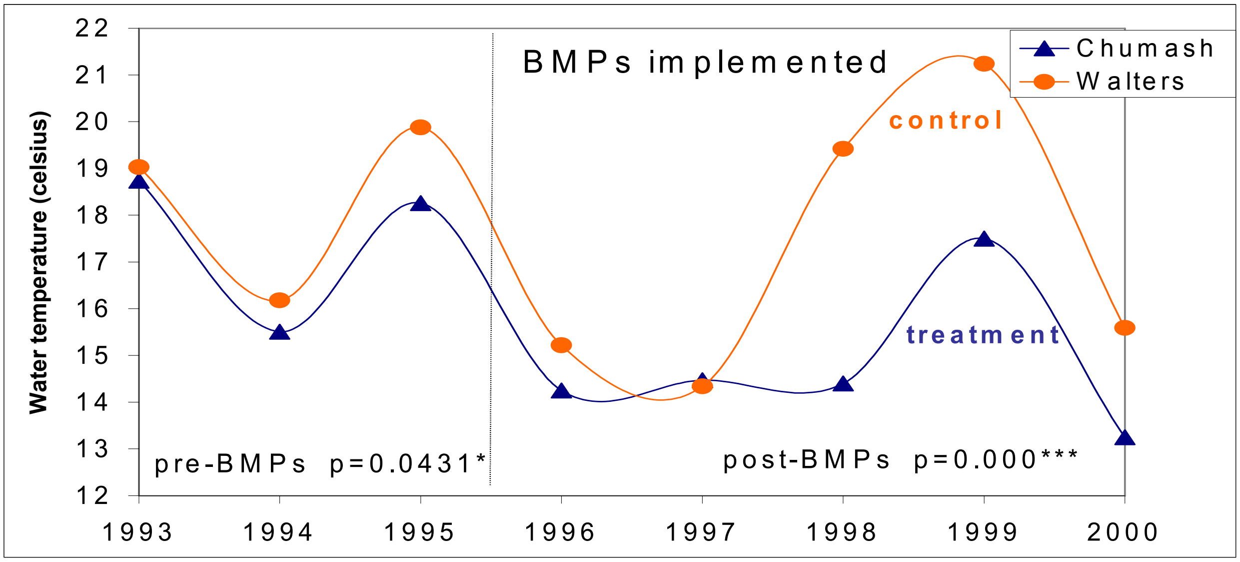

Figure 3.21. Yearly mean water temperature values measured at Chumash and Walters Creeks. The years that were used are water years and start from July 1st and end June 30th. For instance, the water year of 2000 starts July 1st, 2000 and ends June 30th, 2001. The vertical line between 1995 and 1996 marks the time that BMPs were near completion. *α=0.05 ***α=0.001.

In conclusion, water temperature at Chumash Creek dropped significantly in comparison to Walters Creek after BMP implementation. Water temperature is most affected by canopy cover as well as localized shading. Chumash Creek certainly has seen an improvement in creek vegetation. This alone may not account for all the difference seen between water temperatures at the paired sites. A cooling air temperature trend was also noticed between sites in the post-BMP time period. Chumash Creek was approximately one degree Celsius lower in air temperature than Walters Creek (data not presented). Chumash Creek is sampled approximately 30 minutes earlier than Walters Creek; however, this has been the case throughout the entire study and should not result in differences from pre to post-BMP implementation. Lastly, Chumash Creek has a small spring that surfaces roughly 50 meters upstream of the sampling site. It is unknown whether the spring activity is a result of watershed improvements or climatic changes since the drought.

Dissolved Oxygen

While dissolved oxygen concentrations decreased at Chumash Creek following BMP implementation, overall conditions relating to this parameter may have improved. Figure 3.22 and 3.23 display representative weekly even-interval dissolved oxygen for pre-BMP implementation and post-BMP implementation. Only one year of paired data for each figure is presented for easier viewing. Because Walters Creek typically becomes dry in early summer, the paired data used in the figures only extends from December until June. In 1995, during the pre-BMP period (Figure 3.22), dissolved oxygen between creeks is similar until spring when super-saturated conditions at Walters Creek occur. In 2001, during post-BMPs (Figure 3.23), a large difference between dissolved oxygen is apparent between creeks with Walters Creek having higher dissolved oxygen throughout 1999. Statistical analysis of the data collected for the entire study, pre- and post-BMP implementation, confirms the visual difference found between these figures.

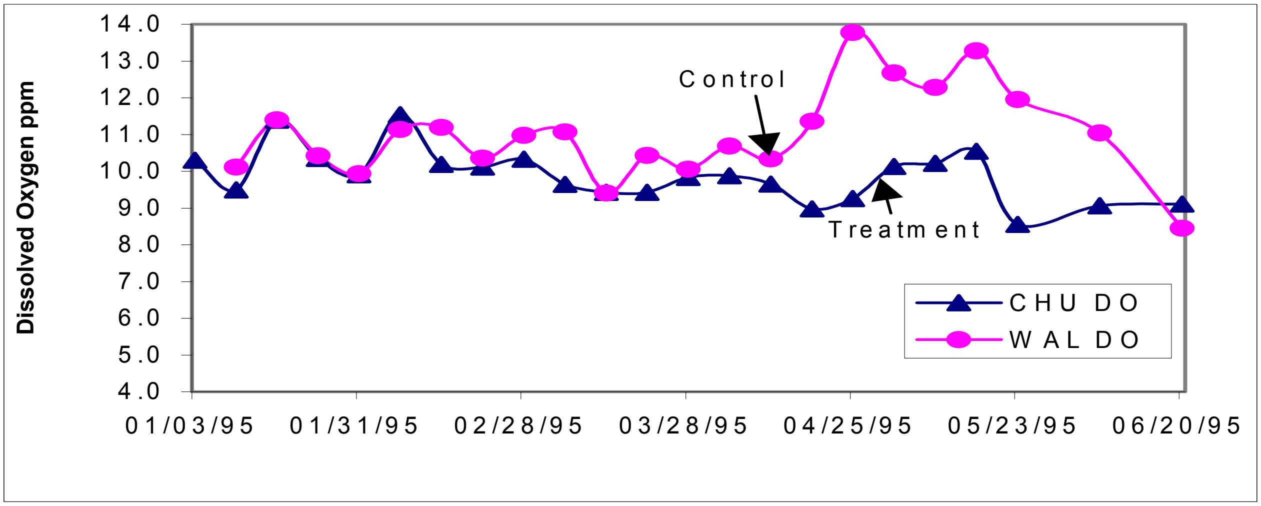

Figure 3.22. 1995 weekly even interval dissolved oxygen concentrations for Chumash and Walters Creek representing pre-BMP implementation in the Chumash Creek watershed.

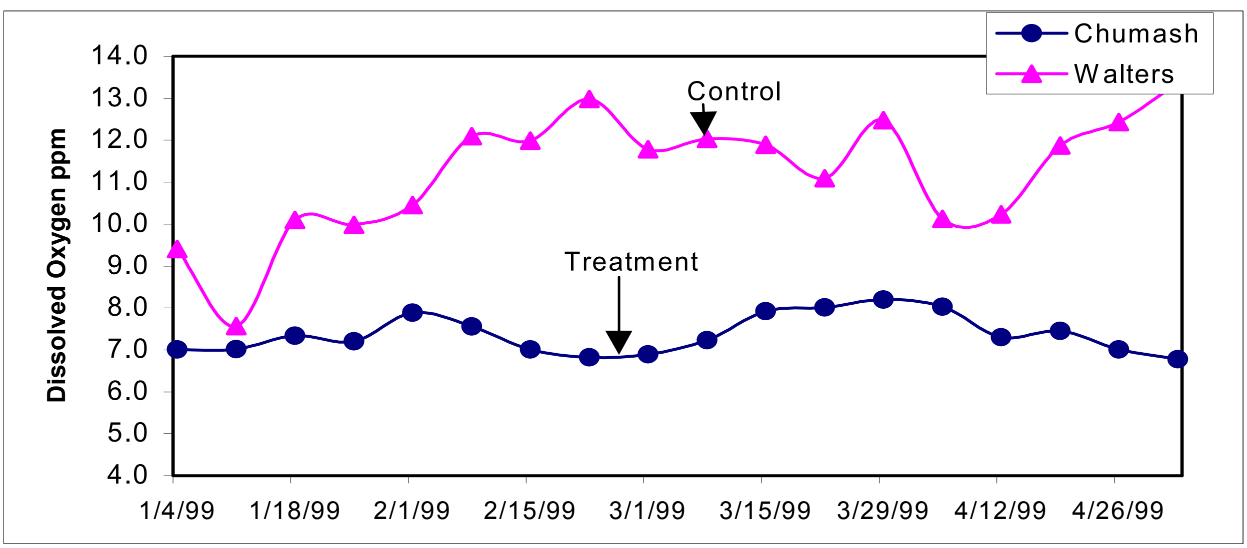

Figure 3.23. 1999 weekly even interval dissolved oxygen concentration (ppm) for Chumash and Walters Creek representing post-BMP implementation in the Chumash Creek watershed.

During the pre-BMPs calibration period, a difference of 0.54 ppm existed between the Creeks with Chumash Creek averaging 9.47 ppm. Walters Creek had an overall average of 10.01 ppm for the entire study. A drop of 1.30 ppm at Chumash Creek resulted in the years following BMP implementation (Table 3.14).

Table 3.14. Statistical results for dissolved oxygen (ppm)

Time Period	Walters Creek-control	Chumash Creek-treatment	p value
Pre-BMP mean	10.01ppm*[1]	9.47ppm	0.0150*
Post-BMPs mean		8.17ppm	0.0001*

*α=0.05 **α=0.01, *[1]The mean of Walters Creek dissolved oxygen for the study. It is used as the intercept for the regression model (see page 7 for further explanation).

From 1993 to 2001, the mean dissolved oxygen level of the Morro Bay watershed is 9.02 ppm with half of the data falling between 8.04 ppm (25th percentile) and 10.01 ppm (75th percentile). The dissolved oxygen water quality objective for cold water fisheries (Regional Board 1994 Basin Plan) is a minimum of 7.0 ppm. The mean dissolved oxygen level in Chumash Creek is 8.17ppm. (see Figure 3.20).

Chumash Creek dissolved oxygen levels are less variable in the post-BMP time period than the pre-BMP time period. Walters Creek has supersaturated dissolved oxygen values (≥ 10.0ppm) and a greater variance than Chumash Creek. As with other water quality parameters collected at Chumash and Walters Creek, dissolved oxygen was collected between 11:00 A.M. and 1:00 P.M where oxygen levels may be approaching a daily maximum. A period of approximately thirty minutes existed between samples, with Chumash Creek always being sampled first.

Because water temperature has decreased at Chumash Creek in the post-BMP time period, it would be expected that higher dissolved oxygen levels would be observed, however, this was not the case. Increased biological activity in the channel may impact dissolved oxygen concentrations. In addition to water temperature, photosynthesis, respiration, and free ions can affect dissolved oxygen (Cole, 1975). For example, decaying algae or other plant matter can consume oxygen.

An important consideration in the interpretation of this data is the diurnal fluctuation of dissolved oxygen. Walters Creek dissolved oxygen levels are higher on average than those in Chumash Creek. Elevated means may in part be due to super-saturated conditions resulting from algae growth and low flow conditions. Walters Creek displayed greater fluctuations in dissolved oxygen throughout the study period. Dissolved oxygen concentrations in Chumash Creek have become, if anything, stabilized in the post-BMP time period. While this cannot be confirmed without pre-dawn measurements, the decrease in variability indicates less diurnal fluctuation suggesting dissolved oxygen levels are healthier in Chumash Creek.

Figure 3.24 displays yearly means (averages) through the entire study period. A vertical line separates the approximate time BMPs implementation was completed. Following BMP implementation, however, the difference between means increases, with Walters Creek continuing to have higher mean dissolved oxygen levels.

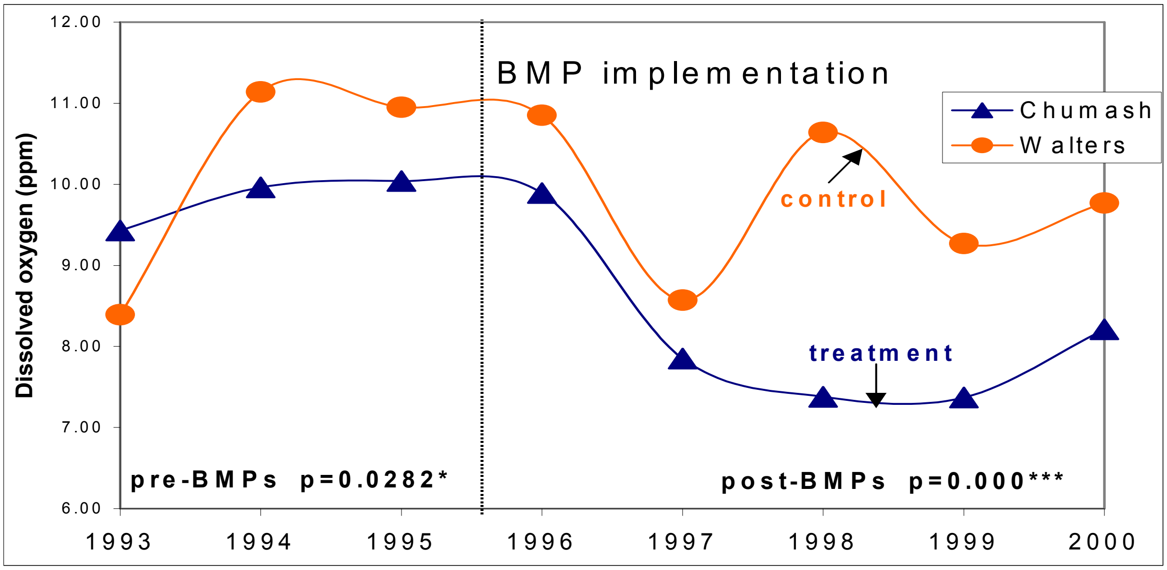

Figure 3.24. Yearly mean dissolved oxygen values measured in Chumash and Walters Creeks. *α=0.05 ***α=0.001

Turbidity

Chumash Creek was found to have little change in turbidity levels between pre- and post- BMP implementation time periods. Similar results occurred at Walters Creek. In fact, levels were near identical between the creeks for both time periods when using 50 NTUs as a threshold value (Table 3.15). Harvey (1989) recommended 50 NTUs to protect salmonids when taking instantaneous readings (25NTUs when measuring over a ten-day period). Turbidity values exceeded the 50 NTU threshold primarily during storm events. Regional Board project staff selected a second threshold value in order to see if differences existed between creeks during low flow periods.

Table 3.15. Contingency table of the binomial distribution of turbidity values pre- and post-BMP implementation at Chumash for storm related conditions (threshold value = 50 NTU).
Included is number of turbidity samples found to be below the 50 NTUs and the number of turbidity samples found to be above 50 NTUs. Also included is the total number of samples, the percentage of samples in both categories, and P values for pre- and post-BMP time periods.

		Chumash Creek-Treatment		Walters Creek-Control	
		number	%	number	%
Pre-BMPs	<50NTUs	45	85	46	87
	≥50NTUs	8	15	7	13
	Total	53	100	53	100
	P value	0.6571			
Post-BMPs	<50NTUs	78	86	78	85
	≥50NTUs	13	14	13	15
	Total	91	100	91	100
	P value	0.7065			

A second threshold value of 7 NTUs (the median of the complete data set) was examined and a significant difference was found in turbidity during the post-BMP time period (p=0.0066**). Chumash Creek has a significant increase in threshold exceedances and also experienced a greater percentage of samples above the threshold of 7 NTUs for the post-BMP time period (57%) than Walters Creek (48%). Figure 3.26 summarizes the results of the logistic binary regression and displays the percentage of samples over 7.0 NTUs for both creeks during both time-periods.

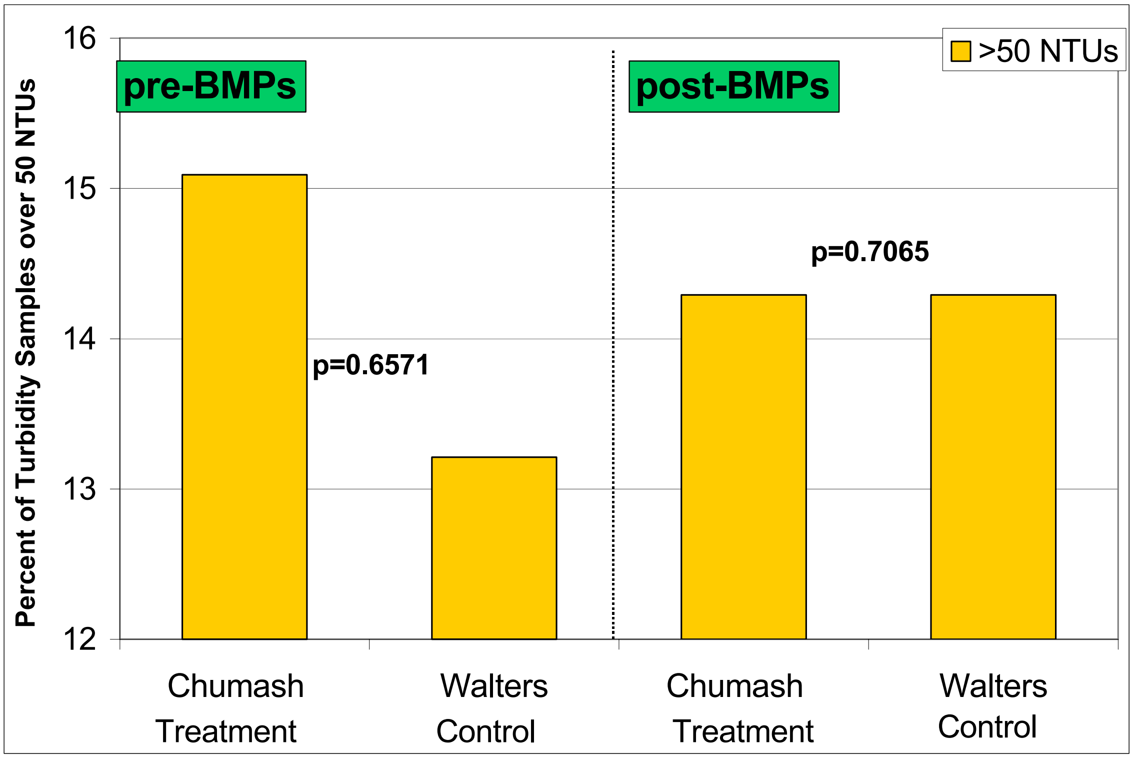

Figure 3.25. Percentage of Chumash and Walters turbidity samples found to be above the threshold of 50 NTUs for the pre- and post-BMP time periods.

Table 3.16. Contingency table of the binomial distribution of turbidity values pre- and post-BMP implementation at Chumash for low flow conditions (threshold value = 7.0 NTU).
Included is number of turbidity samples found to be below the 7.0 NTUs and the number of turbidity samples found to be above 7.0 NTUs. Also included is the total number of samples, the percentage of samples in both categories, and P values for pre- and post-BMP time periods.

		Chumash Creek-Treatment		Walters Creek-Control	
		number	%	number	%
Pre-BMPs	<7.0NTUs	34	64	29	55
	≥7.0NTUs	19	36	24	45
	Total	53	100	53	100
	P value	0.0737			
Post-BMPs	<7.0NTUs	39	43	47	52
	≥7.0NTUs	52	57	44	48
	Total	91	100	91	100
	P value	0.0066**			

**$\alpha \leq 0.01$

In Figure 3.26, the difference in the number of turbidity samples over 7.0 NTUs at Chumash and Walters Creek during pre- and post-BMPs is shown. Pre and post time periods are shown with their appropriate p-scores. In the pre-BMP time period, Walters Creek has a greater number of turbidity samples over 7.0 NTUs and the binary logistic regression model is nearly statistically significant ($\alpha \leq 0.05$). Following BMP implementation, Chumash turbidity samples surpass 7.0 NTUs a higher percentage of the time than Walters Creek samples do, or than Chumash did during the pre BMP period. Little change was found at Walters Creek between periods.

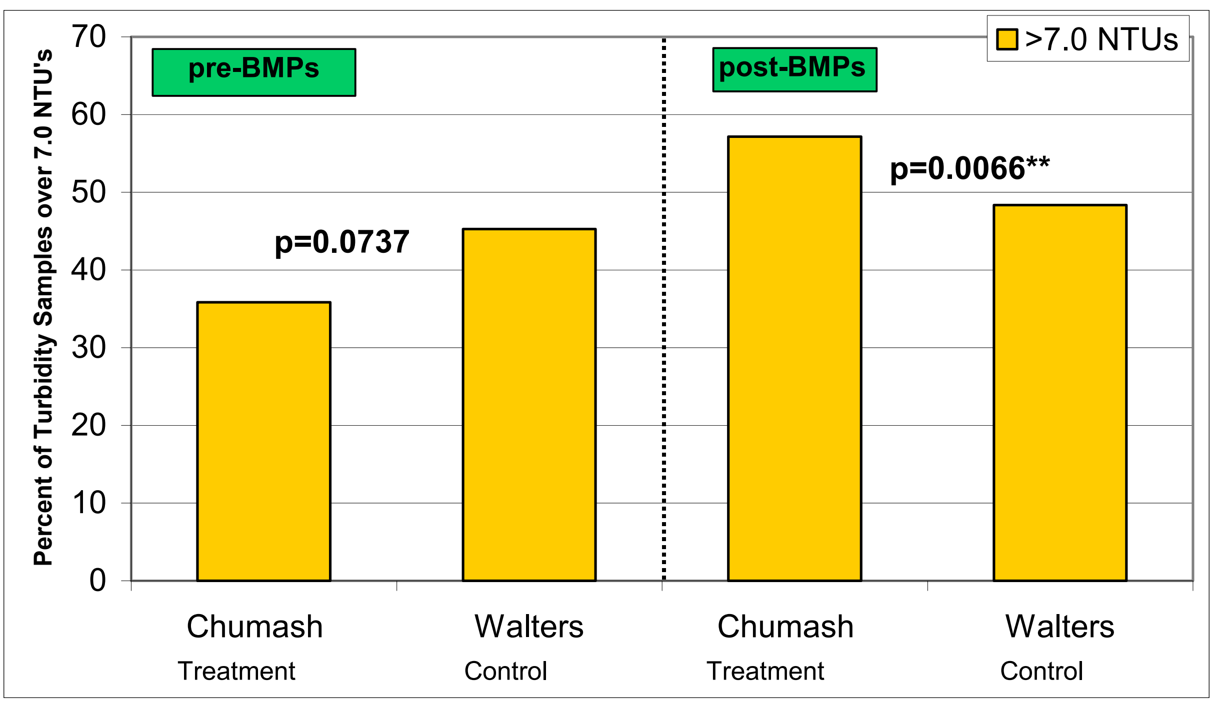

Figure 3.26 Percent of Chumash and Walters Creek turbidity samples found to be over the threshold of 7.0 NTUs for the pre- and post-BMP time periods.
Included are the binary logistic regression p-values.

In summary, the 50 NTU threshold approach was unable to detect a decrease in turbidity. This is contrary to the storm event sampling (as discussed previously). This also supports storm event sampling as the most effective method to detect change in this parameter. During low flow conditions, the 7.0 NTUs threshold approach was able to detect changes in Chumash Creek. Although not as important as storm events when considering sediment transport, it does provide an understanding of average water quality conditions. The increase in turbidity during low flow periods may possibly be related to an improvement in overall habitat quality, as well as increased plant growth and decay associated with the dynamically changing riparian plant community.

Fecal Coliform Bacteria

The removal of cattle should result in lower fecal coliform levels after residual cow feces decompose. Fecal coliform bacteria may survive in cattle feces for up to a year (Bohn and Buckhouse, 1985). Although cattle were not completely excluded from the riparian pastures of Chumash Creek, they were only present in the two main riparian pastures five to ten days a year to graze excess foliage. The upper riparian pasture of Chumash Creek watershed was grazed more extensively in comparison (15-18 days/year) as part of herd rotation through the three watersheds.

When paired with the control creek, Chumash Creek fecal levels have not declined. Both Walters andChumash Creeks have seen a drop in fecal coliform bacteria levels over the study period (especially during winter). Through out the entire study period, Walters Creek has exhibited higher levels of fecal coliform bacteria overall.

Contingency tables below display the number and percentage of samples above and below fecal coliform bacteria threshold values (2000 MPN/100mL for higher flows and 200 MPN/100mL for low flows). An additional row in the contingency table displays the repeated measures binary logistic analysis p-value for both time periods (Table 3.11 and 3.12). Following each contingency table, a bar graph displays the percentage of sample above the threshold for each assigned threshold (Figure 3.27 and 3.28).

The threshold was based on the Regional Board Water Quality Control Plan (Basin Plan, 1994) non-contact recreation standard of ≤ 2000 MPN/100mL to test for differences in high level fecal numbers experienced primarily during winter storm runoff. Results from the analysis found that during pre-BMP implementation, Walters Creek had a higher frequency of fecal bacteria observations over the threshold than did Chumash Creek, but this was not found to be statistically significant ($p=0.1151$, Table 3.17). Following BMP implementation, both creeks showed a decrease in high fecal events (samples ≥ 2000 MPN/100mL). The percentage of high fecal coliform bacteria events at Chumash Creek dropped from 15.09% to 10.99%. Walters Creek dropped from (26.42% to 19.78%) The analysis did not find a significant difference resulting from BMPs implementation.

Table 3.17. Contingency table of the binomial distribution of fecal coliform bacteria values pre- and post-BMP implementation at Chumash Creek during storm related conditions (threshold value = 2000 MPN/100 mL) based on the Regional Board Basin Plan recreational water contact standard).
Included is number of fecal coliform bacteria samples found to be below 2000 MPN/100mL and number of fecal coliform bacteria samples found to be above 2000 MPN/100mL. Also included is the total number of samples, the percentage of samples in both categories, and p- values for both time periods of the study.

		Chumash Creek-Treatment		Walters Creek-Control	
		number	%	number	%
Pre-BMPs	≤2000 MPN	45	85	39	74
	>2000 MPN	8	15	14	26
	Total	53	100	53	100
	P value	0.1151			
Post-BMPs	≤2000 MPN	81	89	73	80
	>2000 MPN	10	11	18	20
	Total	91	100.00	91	100
	P value	0.7482			

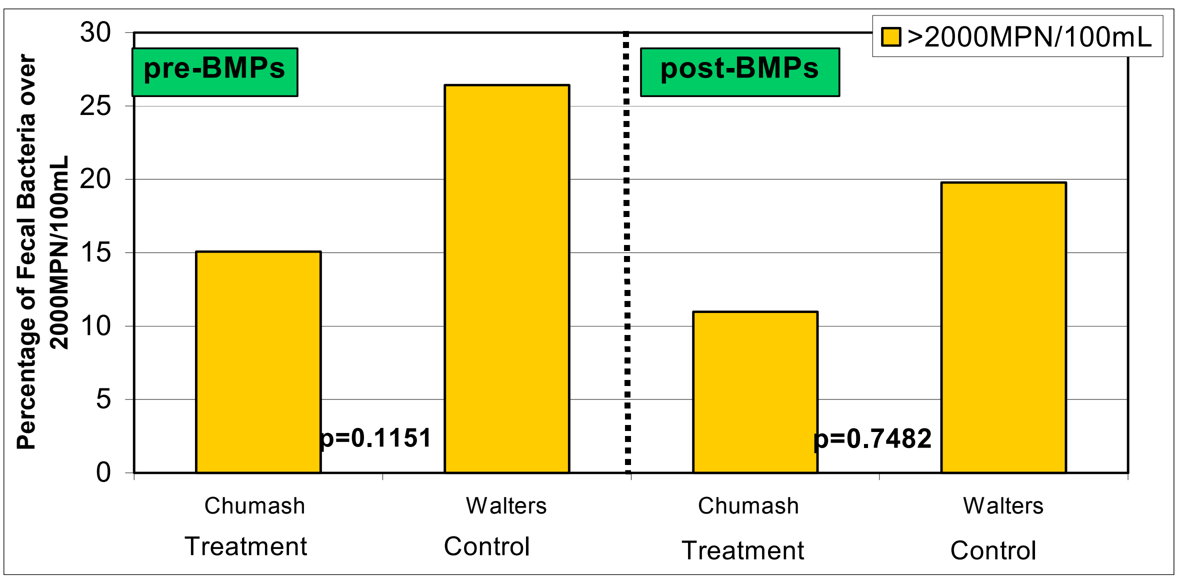

Figure 3.27. Bar graph depicting the frequency of fecal samples at Chumash and Walters Creek found to be over 2000 MPN/100mL (Regional Board 1999 Basin Plan's Non-Contact Recreational limit for fecal coliform bacteria levels) for pre-BMP and post-BMP time periods.
Also, included is statistical analysis p-scores.

A second, lower threshold was selected based on the Regional Board is Basin Plan, 1994 contact recreation standard of ≤ 200 MPN/100mL to test for differences in fecal counts during baseflow to lower flow. Results from the analysis indicated during pre-BMP implementation, Walters Creek had a higher frequency of fecal bacteria observations over the threshold than did Chumash Creek and was found to be statistically significant (p=0.0228, Table 3.18). Following BMP implementation, the percentage of fecal coliform bacteria events over 200 MPN/100mL at

Chumash Creek dropped slightly from 55% to 53%. Walters Creek experienced a greater percent drop in fecal events over 200 MPN/100mL (74% to 64%) therefore, the analysis did not find a significant difference resulting from BMPs (p=0.8492).

Table 3.18. Contingency table of the binomial distribution of fecal coliform bacteria values pre- and post-BMP implementation at Chumash Creek during low flow conditions (threshold value = 200 MPN/100 mL, based on Regional Board Basin Plan recreational water contact standard).
Included is number of fecal coliform bacteria samples found to be below 200 MPN/100mL and number of fecal coliform bacteria samples found to be above 200 MPN/100mL. Also included is the total number of samples, the percentage of samples in both categories, and p- values for both time periods of the study.

		Chumash Creek-Treatment		Walters Creek-Control	
		number	%	number	%
Pre-BMPs	<200 MPN	24	45	14	26
	>200 MPN	29	55	39	74
	Total	53	100	53	100
	P value	0.0228*			
Post-BMPs	<200 MPN	43	47	33	36
	>200 MPN	48	53	58	64
	Total	91	100	91	100
	P value	0.8492			

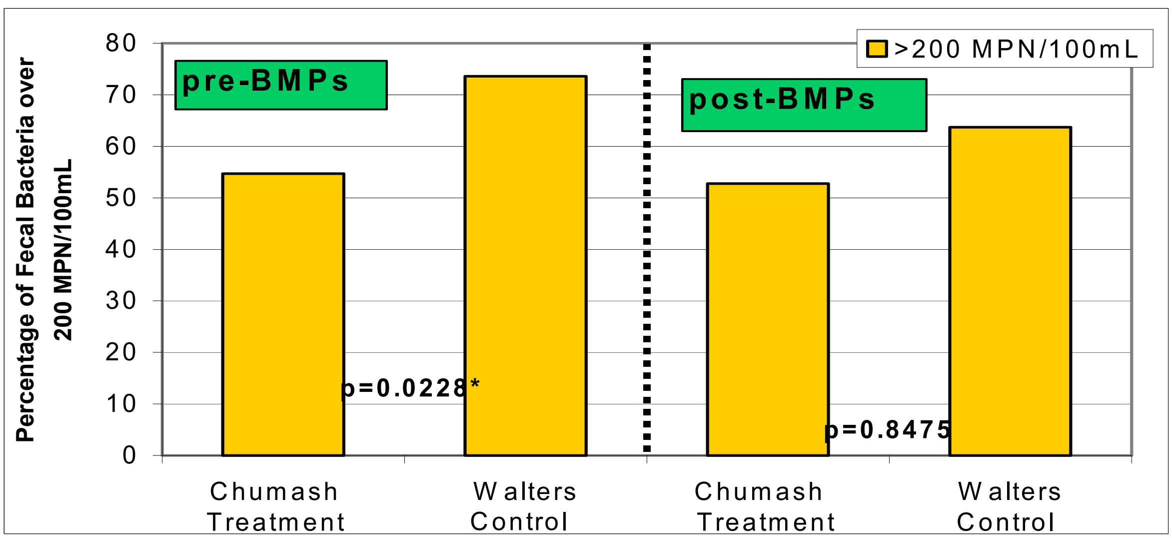

Figure 3.28. Bar graph depicting the percentage of fecal samples at Chumash and Walters Creek found to be over 200 MPN/100mL (Regional Board 1999 Basin Plan's Contact Recreational limit for fecal coliform bacteria levels) for pre-BMP and post-BMP time periods.
Also, included is statistical analysis p-scores. $^*p \leq 0.05$

In conclusion, using either a threshold of 2000 MPN/100mL (high flow) or 200 MPN/100mL (low flow), percent of threshold exceedance at Chumash Creek was found to be lower than on Walters Creek during the pre-BMP time period. After BMPs were installed in the Chumash Creek watershed, percent exceedances of fecal coliform decreased, primarily for the high-flow threshold. However, percent exceedances of fecal coliform thresholds on Walters Creek also decreased. As a result, the effectiveness of BMP implementation at Chumash Creek is not readily apparent.

There are several reasons fecal coliform bacteria levels may not have improved at Chumash Creek when compared to Walters Creek. There was relatively frequent access of cattle to the upper reaches of the Chumash Creek's riparian corridor (pasture EU07). Additionally, the cattle spent less time overall in the Walters Creeks watershed. Additionally, an increase in wildlife was noted at Chumash Creek in comparison to Walters Creek (Allyson Young, personal communication, 2002).

Nutrients

The reported effects of ranching on stream nutrients (nitrate-nitrogen and ortho-phosphate) have varied from study to study (Baurer and Burton, 1993). Nutrient enrichment of creeks is dependant on density of the herd, proximity of herd to the creek, health of the pasture, and health of the riparian corridor. Because Chumash and Walters Creek flow into Chorro Creek, which drains into Morro Bay Estuary, limiting nutrient input is important. Chorro Creek is listed on the 303(d) list as impaired by nutrients. EPA (1989) recommends that total phosphate levels not exceed 0.050 mg/L where it enters a lake or reservoir and not exceed 0.100 mg/L for all other streams. Also, it is recommended that nitrate-nitrogen not exceed 0.300 mg/L. Average nitrate (N03-N) concentrations in 19 sites sampled throughout the Morro Bay watershed were 1.2 mg/l, while mean concentrations at Chumash and Walters Creeks were 0.38 and 0.29 mg/l respectively.

Using repeated measure binary logistic regression, a significant increase was observed in nitrate-nitrogen occurrences following BMP implementation. Regional Board project staff chose a threshold value of 0.700 mg/L based on a median of all samples. During the pre-BMP time period, there was no difference in the frequency of nitrate-nitrogen values above or below the threshold value of 0.700 mg/L at Chumash and Walters Creeks (Table 3.19). Following BMP implementation, the percentage of samples at Chumash Creek above the threshold of 0.700 mg/L doubled from 32% to 64%, and was significant (p=0.0001). Walters Creek percentage for nitrates also increased but was not significant (32% pre-BMP, 38% post-BMP). It is important to note that nitrate levels in Chumash Creek are now similar to those found in the Morro Bay watershed.

Table 3.19. Contingency table of the binomial distribution of Nitrate-Nitrogen values pre- and post- BMP implementation at Chumash Creek (threshold value = 0.700 mg/L).
Included is number of Nitrate-Nitrogen samples found to be below 0.700 mg/L and number of Nitrate-Nitrogen samples found to be above 0.700 mg/L. Also included is the total number of samples, the percentage of samples in both categories, and p- values for both time periods of the study.

		Chumash Creek-Treatment		**Walters Creek-**Control	
		number	%	number	%
Pre-BMPs	<0.700 mg/L	36	68	36	68
	≥0.700 mg/L	17	32	17	32
	Total	53	100	53	100
	P value	0.7166			
Post-BMPs	<0.700 mg/L	33	36	46	62
	≥0.700 mg/L	58	64	45	38
	Total	91	100	91	100
	P value	0.0001***			

***α=0.001

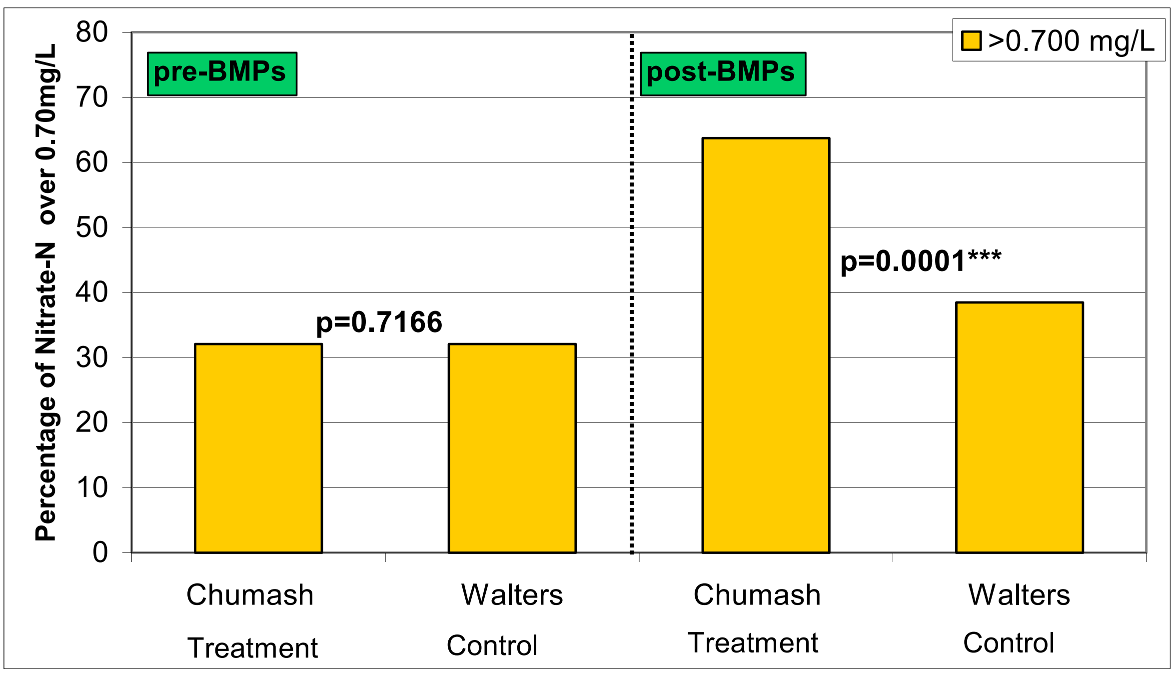

Figure 3.29. Bar graph depicting the percentage of Nitrate-nitrogen samples at Chumash & Walters Creek found to be over 0.700 mg/L (median of data set) for pre & post BMP time periods.
Also, included is statistical analysis p-scores.

Chumash Creek, the treatment creek, often surpasses Walters Creek, the control creek, in nitrate-nitrogen concentrations, particularly during the summer providing support for statistical conclusions. Due to the very low nitrate-nitrogen levels at Chumash Creek, the increase in number of days levels attained or exceeded the threshold level of 0.700mg/L NO3-N post-BMP implementation may actually be a sign of improvement.

Ortho-phosphate was measured in Chumash and Walters Creek, however, much of the pre-BMP period data were not usable for analysis because the minimum detection limit (0.100 mg/L) was higher than the majority of the entire data set. In 1995, Regional Board contracted with a new laboratory, which used a lower detection limit (0.020 mg/L). However, Staff was able to evaluate datausing a data set from 1996-2001 to analyze trends.

Ortho-phosphate levels in Walters Creek were higher that those in Chumash Creek, and have declined at both creeks since 1997. Significant differences were not found between the two sites, suggests that BMPs were not effective in reducing ortho-phosphate levels.

3.3.6 Even-Interval Water Quality Conclusions

Results of five years of BMP implementation in the Chumash sub-watershed indicate that overall water quality is improving. The weekly sampling objectives to track improving water temperature and maintaining healthy levels of dissolved oxygen were met. BMPs improved water temperature at Chumash Creek by lowering mean levels. Water temperature at Chumash Creek improved most likely from the increases in riparian and instream vegetation. Proliferation of willows (*Salix lasiolepis*) shading the water surface in many areas have helped to decrease the water temperature. Western sycamores (*Platanus racemosa*) are also contributing in a few areas. Sedges and rushes have also combined with canopy vegetation to lower the water temperature in comparison to the control creek. Coast live oaks (*Quercus agrifolia*) have also been planted along Chumash Creek. Their growth is slow and will not provide shading for many years to come, but will become one of the dominant trees in late plant succession.

While dissolved oxygen significantly decreased at Chumash Creek, levels are less variable in the post-BMP time period than the pre-BMP time period. Aquatic photosynthetic plants provide the majority of dissolved oxygen to creeks (Cole, 1975). However, respiration at night can cause a drastic decrease in dissolved oxygen. Additionally, because of the increase in plant life, there is also more organic material to decay, which for many microorganisms requires oxygen. Over time, the continued stabilization of dissolved oxygen levels is expected.

Turbidity exceeded the threshold values more often at Chumash Creek than at Walters Creek. The winter-spring even-interval sampling conducted by the Regional Board resulted in statistically significant differences in turbidity when using the threshold of 7 NTUs, but not the threshold of 50 NTUs. At Chumash Creek, cattle are excluded from the lower portion of the watershed except for a few days during dry months. It is likely that the increase in turbidity during low flow periods may be due to an improvement in overall habitat quality, and increased algae populations and suspended organic debris in the creek. Neither of these were monitored, so no quantitative analysis can be performed to understand their influence on turbidity during low flows at Chumash Creek. Recall that Chumash Creek has significantly lower event turbidity mean than Walters Creek during storm events (discussed previously). This suggests that storm event monitoring is more effective at detecting changes in turbidity, when most sediment is transported.

Nitrate-nitrogen also exceeded the threshold values more often at Chumash Creek than at Walters Creek. Increases in nitrate-nitrogen may be indicative of early riparian succession at Chumash Creek. Several possible explanations exist for observing an increased percent of nitrate exceedances over the threshold value of 0.700 mg/L at Chumash Creek. The most plausible reason is that BMPs have created more diverse habitat. The increase in vegetation has increased organic material, which has increased decomposition, and nitrogen transformations. It should be noted that nitrate values are now more typical of other creeks in the Morro Bay watershed.

The number of fecal coliform bacteria exceeding the threshold did not significantly change during the entire study period. The objective of lowering fecal coliform bacteria was not met possibly due to continued grazing practices in the upper Chumash watershed, grazing through the three watersheds, or potential increases in birds and wildlife.

Chumash Creek is currently in a state of transition to a healthier riparian corridor with a high percent cover of diverse vegetation. Riparian and instream vegetation is dense along and within the channel of Chumash Creek. Changes in water quality can be attributed to the rapid growth of vegetation in and along side the creek and the reduced grazing of cattle in the riparian corridor. Sediments have been trapped within root masses and submerged vegetation. The barriers created by the successional plant community allows water to be pooled in many locations. Alga blooms proliferate between reeds and across subsurface of pools. Dissolved oxygen, water temperature, and turbidity are probably most affected by the early stages of plant succession. It is anticipated that as the canopy matures, shading of the center channel will ultimately reduce these parameters. Continued monitoring of these parameters is recommended.

Five years following BMP implementation, changes have been detected through even-interval sampling and continued changes are expected. Future monitoring could help provide additional long-term trends in the parameters measured in this study.

3.3.7 Rapid Bioassessment

Regional Board project staff conducted Rapid Bioassessment (RBA) at Chumash and Walters Creek in order to assess benthic macro-invertebrate community health. Calculated metrices were used as general indicators of water quality. Habitat assessments were also performed. No pre-BMP implementation samples were taken at Chumash and Walters Creeks, as benthic macro-invertebrate monitoring there began in 1996. Therefore conclusions regarding BMP effectiveness are difficult to draw. Project Staff analyzed the data to evaluate overall trends.

NMP project staff used an Index of Biological Integrity calculated as part of the Central Coast Regional Monitoring Program. Figure 3.30 shows Index of Biological Integrity (IBI) scores at Chumash and Walters Creeks. As shown, results were variable at both creeks.

Figure 3.30. Index of Biological Integrity scores at Chumash and Walters Creeks.

The California Fish and Game categorizes benthic macro-invertebrates taxa according to their feeding strategy. The five feeding strategies are as follows: Shredders, Grazers, Collectors, Filterers, and Predators. Some benthic invertebrates are expected to decrease in overall percentage following perturbation of habitat. These include Grazers, that graze or scrape upon periphyton, and Shredders that shred leaf litter to obtain food. Grazers and Shredders are sensitive to change and less tolerant to degradation in benthic habitat. Collectors (or Omnivores, or Scavengers), on the other hand, are expected to increase in numbers due to a disturbance in the environment. Other feeding categories such as Predators and Filterers are more variable in their response to disturbance (DeShon 1995, Barbour et al. 1996b, Fore et. al. 1996, Smith and Voshell, 1997). The feeding strategy metric Regional Board project staff selected to examine Chumash and Walters Creek benthic macro-invertebrate communities is percent Grazers.

From 1997-2001, Regional Board project staff detected a decline in Grazers at both Chumash and Walters Creek (Figure 3.31). Collectors were found to be the main feeding strategy followed by Filterers, both of which have replaced Grazers as they have declined. Collectors and Filterers are variable through the years (not shown) with Collectors usually being the dominant feeding strategy. Based on past studies (Barbour, 1999), this implies an increase in perturbation at both creeks. However, small, predominantly sandy bottom creeks may not be typical in these studies and the short time frame of study makes conclusions difficult to draw.

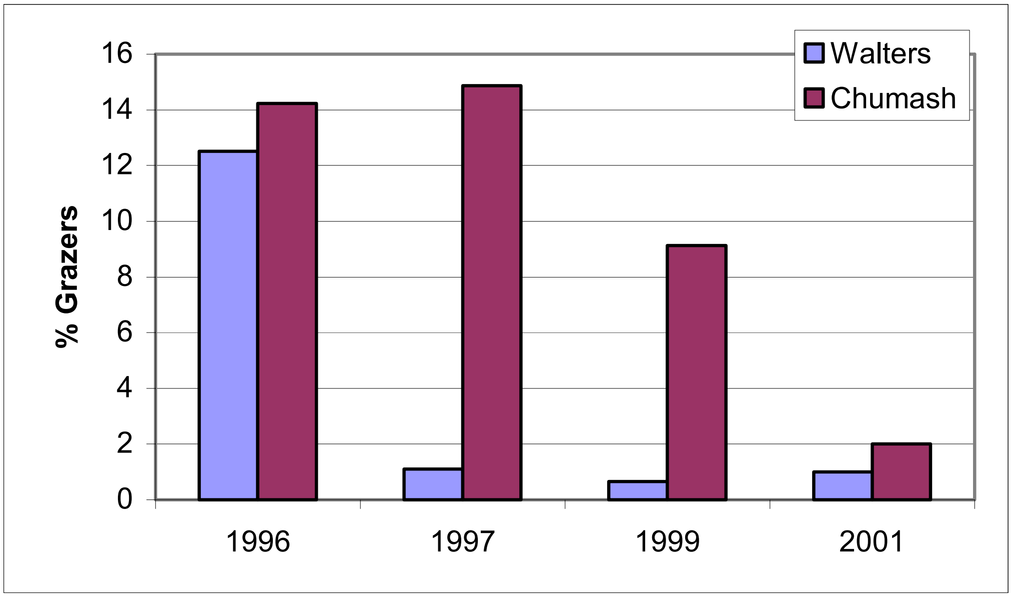

Figure 3.31. The percent of the benthic macroinvertebrate feeding strategy Grazers, found in Chumash and Walters Creeks rapid bioassessment samples for 1996, 1997, 1999, and 2001.
Note: all data is post-BMP.

Two richness metrices are examined for Chumash and Walters Creek, Taxonomic Richness and EPT Taxa Richness. Taxonomic Richness is the number of taxa (genera and some families in our case) present in a sample. EPT Taxa Richness is the number of taxa representing mayflies (*Ephemeroptera spp*), stoneflies (*Plecoptera spp*), and caddisflies (*Trichoptera spp*) in each sample. These taxa are sensitive and intolerant to pollutants. Their numbers are expected to decrease with disturbance to habitat and increase as water quality and/or habitat improves.

As shown in Figure 3.32, the number of taxa varied slightly from year to year in each creek, but did not change significantly. Walters Creek has a greater number of taxa in 1999 and 2001.

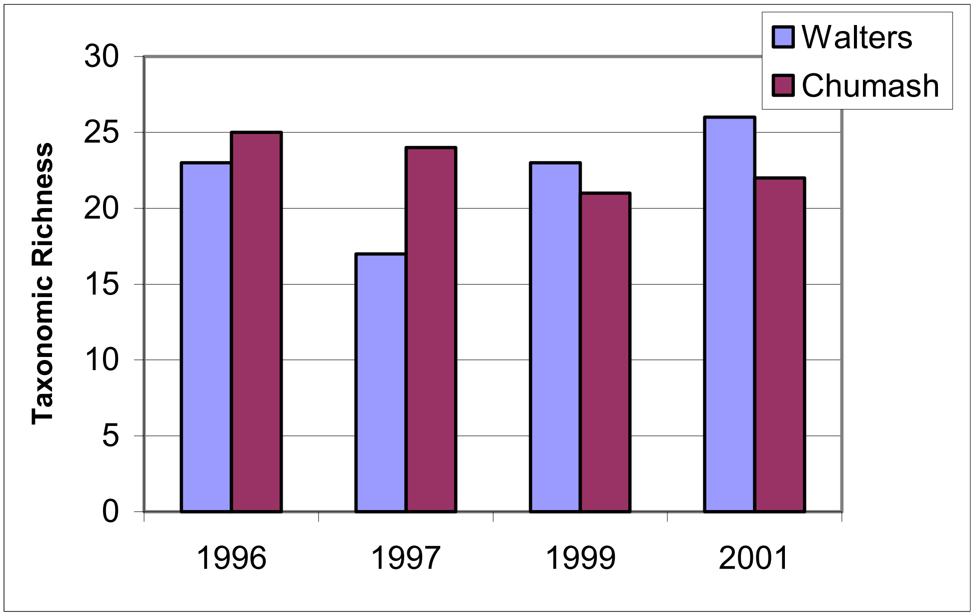

Figure 3.32. Taxonomic richness present in Chumash and Walters Creek samples for 1996, 1997, 1999, and 2001.
Note: all data is post-BMPs.

EPT Taxa Richness has improved at Walters Creek and has fluctuated at Chumash Creek through the years sampled. Chumash Creek had the greatest number of EPT Taxa present in 1999 (eight taxa present, Figure 3.33), but declined in 2001 to three taxa. Walters Creek had only two EPT Taxa present in 1996 and 1997, but then increased to 6 and then 7 in 1999 and 2001 respectively. Richness metrices imply that Walters Creek benthic invertebrate community may be improving, but without pre-BMP data, conclusions are difficult to draw.

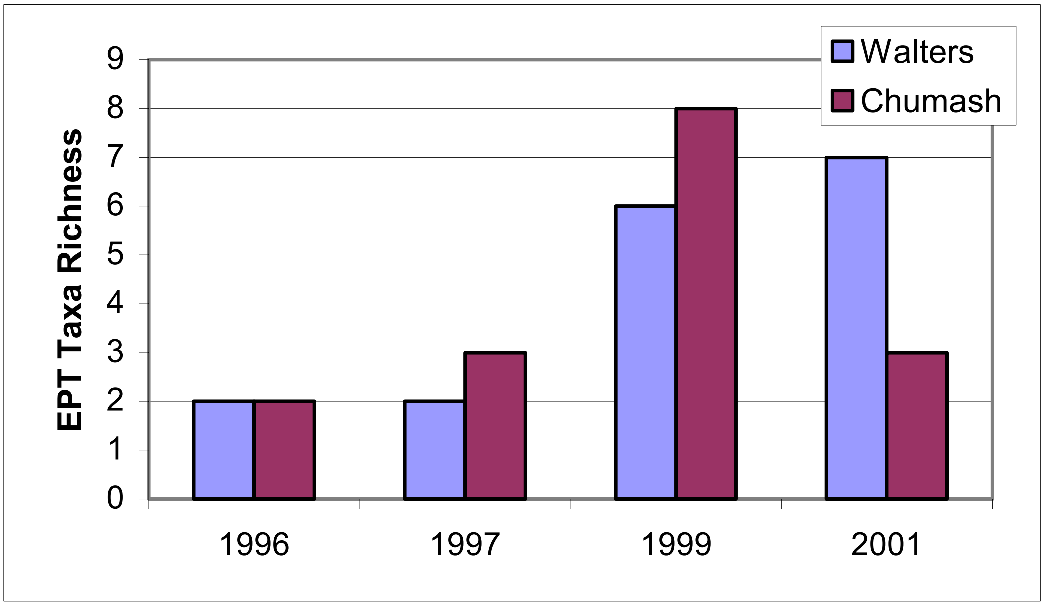

Figure 3.33. EPT Taxonomic Richness at Chumash and Walters Creek for 1996, 1997, 1999, and 2001. Note: all data is post-BMPs.

Although Taxonomic Richness provides a measure of taxa present, it does not provide insight into taxa distribution. The Percent Dominant Taxon metric is the percent of the sample dominated by the most abundant taxon (genus is used). The Percent Dominant Taxon metric is expected to increase with an increase in perturbation.

The Percent Dominant Taxon metric fluctuated in both creeks during the years sampled. Chumash Creek data never exceeded 40% and is found to be below 30% for two of the four years sampled (Figure 3.34). Walters Creek exceeded 70% in one year, but in general trends are not evident.

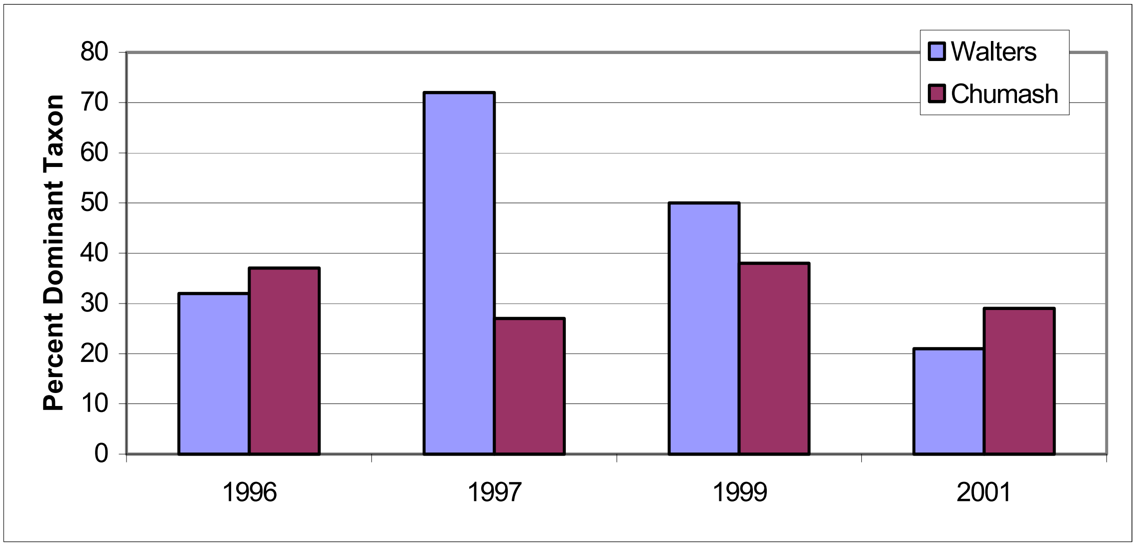

Figure 3.34. Percentage of the dominant macro-invertebrate taxon at Chumash and Walters Creek for 1996, 1997, 1999 and 2001.
A percent dominant taxon is defined as the percent of the sample dominated by the most abundant macro-invertebrate taxon (genera). Note: all data is post-BMP.

Conclusions

The absence of Rapid Bioassessment data from the pre-BMP period makes conclusions about benthic invertebrate assemblages difficult. As mentioned in the even-interval section, sedimentation upstream and around the flume created a wetland system with very low gradient pools and short slow moving riffles. A reduction in suspended sediment during storm events has been documented. Chumash Creek has had an increase in channel vegetation and has captured large quantities of sediments (in fact, enough that dredging was required to maintain the flume's operation). This natural filling may have had an impact on communities in the creek.

More data is needed to provide a more complete picture of benthic macro-invertebrate community health at Chumash and Walters Creeks. Rapid Bioassessment monitoring will continue by the Morro Bay Volunteer Monitoring Program in future years and will aid in this effort.